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ABSTRACT

This document reports on a study into the relationships between cognitive preferences, achievement, and ethnicity of first year algebra students. The sample consisted of 175 students from two high schools in the Denver (Colorado) metropolitan area. The two schools were chosen because of the diversity of ethnic groups in the student populations. Included in this study were 72 Hispanics, 48 Blacks, 33 Anglos, and 22 Orientals. A cognitive preference test was administered to the students during March, 1987, and an achievement test for first year algebra was administered during the latter part of May, 1987. The results of the study indicated that: (1) Oriental students had significantly higher graphic scores than Black students; (2) Hispanic students had significantly higher verbal scores than Oriental students; and (3) Black students had significantly higher symbolic scores than Hispanic students. (TW)

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COGNITIVE PREFERENCES AND ETHNICITY

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INTRODUCTION

The concept of the "Cognitive Preference Test" originated in the early 1960's in response to widespread curriculum reform efforts. Cognitive preferences were defined by Heath (1964) to be the "differing modes of attending to the subject matter of a course" (p.241). The test which he developed was called the Cognitive Preference Test: High School Physics (CPT:HSP). Heath explained his test in this way:

> "The interest is not in whether the student can identify correct or incorrect information but rather in what he is likely to do with information intellectually (p.241)."

A small amount of research has been done in the area of mathematical cognitive preferences. O'Donnell (1975) studied the effects of student and teacher cognitive preferences on achievement in junior high school mathematics. As a result of this study the following conclusions were made:

1) The interaction between teacher and student cognitive preferences does not have a significant effect on either computation or concept achievement.

2) The cognitive preference of the student has no significant effect on either computation or concept achievement.

3) The cognitive preference of the teacher has no significant effect on computation achievement. The teacher's cognitive preference may have an effect on concept

achievement, however, with the students of "symbolic" teachers achieving slightly higher.

Behr and Eastman (1978) studied the cognitive preferences of university freshman and university senior preservice and inservice elementary school teachers. They found that these subjects did exhibit a wide range of preference scores. Additionally, significant differences were found in cognitve preference scores for the three groups. Behr and Eastman concluded that "it appears that some support exists to substantiate the conjecture that groups of people with different experiences or training exhibit a different cognitive preference (p.31)."

Using the same cognitive preference test as O'Donnell, Endsley (1983) studied the effects of cognitive preference, sex, and attitude toward mathematics on achievement in a first-year algebra course. He concluded that a student's cognitive preference for learning mathematical facts was not significantly related to achievement.

The authors of this study, having both taught in a school district with large ethnic populations, have been aware of the concern for the divergent achievement levels of different ethnic groups. Also, through experience it was considered probable that different ethnic groups display different cognitive preference scores. This study was undertaken to answer the following questions:

(1) Is there a difference in the cognitive preference scores of first year algebra students when they are classified by ethnic group?

(2) Are cognitive preference scores related to achievement in first year algebra?

(3) Is there an interaction effect of ethnicity and achievement level on cognitive preference scores?

SAMPLE

The sample consisted of 175 students from two high schools in the Denver metropolitan area. The schools were chosen because of student populations which contain a good mix of four ethnic groups. Included in this study were 72 Hispanics, 48 Blacks, 33 Anglos, and 22 Orientals.

For the purpose of this study seven sections of first year algebra students were used. The classes were taught by four teachers.

PROCEDURE

The Cognitive Preference Test: Mathematics (Revised)(CPTM) was administered during March, 1987. An achievement test for first year algebra was administered during the latter part of May, 1987.

The CPTM is a thirty-two item revision of an earlier test (Travers, Heath, and Cahen, 1967). The content is math specific. Content validity was established by a panel of experts. Each test item consists of three choices relating to the same topic. The subjects must read all three choices to determine the mathematical idea that they have in common.

The subjects are asked to select which of the three ways they would like to have the idea explained to them. The test yields an ipsative score for graphic, verbal, and symbolic choices. O'Donnell (p.27) reported reliability coefficients (Spearman-Brown "Prophecy Formula") of .91 for the graphic preference, .91 for the verbal preference, and .90 for the symbolic preference. Mean cognitive preference scores obtained in this study for the experimental sample were 3.97, 6.08, and 21.81 for the graphic, verbal, and symbolic preferences respectively.

The achievement test was a forty item objective based instrument. It was written by a committee of algebra teachers, none of whom were included in the study. The teachers who administered the test were also asked to establish content validity. All agreed that the material in the test was appropriate for their classes. No norms have been established for the achievement test. It does appear, though, to distinguish among students of different abilities. Descriptive statistics for the test are listed in Table 1. The distribution of achievement scores appears to be very close to normal.

In the previous research of O'Donnell and Endsley the subjects were classified on the basis of their cognitive preference scores. Some measure of achievement was then used as the dependent variable. This technique resulted in the exclusion of students of all ability levels who may have been equally comfortable using any of the preference options. The present investigators felt that this exclusion

of subjects could adversely skew the population and mask statistically significant relationships. For part of this study the student's cognitive preference scores were used as the dependent variable. The student's ethnicity and achievement level were used as the independent variables.

For purposes of this study the students were placed in the high or low achievement group based on their achievement test score. The high group was composed of those students scoring above the mean while the low group scored below the mean.

All data were analyzed using a one or two factor analysis of variance (ANOVA) model. Because unequal cell sizes were used in the study, the ANOVA was completed using multiple regression techniques (Glass and Hopkins, 1984, p.444).

RESULTS

The results of the 4x1 ANOVA for the CPTM scores are reported in Tables 2, 3, and 4. In all three cases the F ratio was significant at the .05 level. This indicates that the ethnic groups differ in their graphic, verbal, and symbolic scores. In order to determine which groups differed on each scale, the Newman-Keuls (NK) method of multiple comparisons was applied to the data. The results of these comparisons are presented in Tables 5, 6, and 7. Any means which are underscored by the same line do not significantly differ. The results of the multiple

comparisons can be summarized as follows: (a) Oriental students have significantly higher graphic scores than Black students, (b) Hispanic students have significantly higher verbal scores than Oriental students, and (c) Black students have significantly higher symbolic scores than Hispanic students.

Tables 8, 9, and 10 present the results of the 4x2 ANOVA which was performed to investigate the interaction effect of ethnicity and achievement level on cognitive preference scores. The interaction of ethnicity and achievement level was significant at the .05 level on graphic scores. Figure 1 illustrates the nature of this interaction.

The results of a one factor ANOVA for student achievement are reported in Table 11. The F ratio was significant at the .001 level. An NK post hoc analysis was performed and the results are shown in Table 12. The analysis revealed that the achievement scores for the Hispanic, Anglo, and Oriental subgroups are not significantly different while the scores of the Black subgroup are different from every other subgroup.

Because of the achievement and cognitive preference differences, ANOVA was performed three additional times using achievement as the dependent variable. Each analysis used a subgroup of the Black sample.

The Black sample used for Table 13 was composed of those students with a graphic score above the Black mean graphic score and a symbolic score below the symbolic mean

for the Black students. The Black students used for Table 14 scored above the Black mean on the graphic scale. The Black students used for Table 15 scored below the Black mean on the symbolic scale. The F ratios in Tables 13 and 15 were not significant at the .05 level, indicating no difference in mean achievement scores among ethnic groups.

DISCUSSION AND IMPLICATIONS

The findings of this study confirm that different ethnic groups exhibit different cognitive preferences. Although differences were thought to be probable, their exact nature was unknown. The lower achievement scores for the Black students were not surprising. The 1986 summary of ACT and SAT scores for Colorado show Black students trailing Anglo and Oriental students. Surprisingly, although Hispanic students tend to score lower than Anglo and Oriental students on the same tests, the Hispanics in this study scored as well on the algebra test as the aforementioned groups. The reason for this can no doubt be partially found in the similarity, with one exception, of the preference scores of these three groups.

One of the most interesting findings was the difference between the verbal scores for the Hispanic and Oriental students. The low Oriental preference might be explained by the large number of immigrants arriving in this country in the past decade. The much higher Hispanic score was considered unusual in that poor language/verbal skills are

often given as a reason for diminished achievement in the Hispanic population. In this study not only did the Hispanic students show a greater preference for verbal statements, but their achievement was on the level with the Anglos and Orientals. The authors conclude from this contradiction that the verbal preference does not affect achievement in first year algebra.

Also of note were the extreme graphic and symbolic scores for the Black students. The ANOVA for the subgroups of Blacks revealed that those students whose symbolic preference scores were near the mean of the other groups performed as well on an achievement test. In contrast to the earlier work of O'Donnell and Endsley, this is the first study in which cognitive preferences appear to be related to achievement. It is possible that an extreme preference score, to the exclusion of the other preferences, hinders learning. It may also be that it is the symbolic preference that has the greatest effect on achievement. Regardless, it would be desirable to determine if the preferences of a student can be changed through instruction. Research in social studies suggest that they can be (Atwood and Rogers, 1974). Additionally, research should be undertaken to determine if a Black student's achievement level can be raised by the modification of an extreme symbolic preference through instruction. The origins of these extreme symbolic preferences might also be investigated.

Although the interaction of ethnicity and achievement produced a significant effect, the meaning and implications

of this finding are unclear to the investigators. It may serve as a point of departure for further research.

Because this is the first study to find cognitive preference effects on achievement, the investigators would suggest a replication with more factors taken into account. Greater attention should also be paid to possible interaction effects.

A limited number of copies of the CPTM is available from the authors for research purposes.

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Descriptive Statistics
Achievement Test

n=175

Mean:	14.246	Median:	14	Mode:	14
St. Dev.:	4.877	St. Err.:	.369		
Skewness:	.271	Kurtosis:	-.447		

Table 1

Analysis of Variance

Graphic Preference

Source	SS	df	MS	F	prob
Ethnicity	166.706	3	55.569	2.885	.037
Within	3294.152	171	19.264		

Table 2

Analysis of Variance

Verbal Preference

Source	SS	df	MS	F	prob
Ethnicity	271.641	3	90.547	2.684	.047
Within	5769.239	171	33.738		

Table 3

Analysis of Variance

Symbolic Preference

Source	SS	df	MS	F	prob
Ethnicity	421.592	3	140.530	2.692	.047
Within	8925.802	171	52.198		

Table 4

Newman-Keuls Post-hoc Analysis

Graphic Preference

Group	Oriental	Hispanic	Anglo	Black
Group Mean	5.909	4.333	3.666	2.75 *

*Significant at .05 level

Table 5

Newman-Keuls Post-hoc Analysis

Verbal Preference

Group	Hispanic	Anglo	Black	Oriental
Group Mean	7.125	6.939	4.916	3.909 **

**Significant at .10 level

Table 6

Newman-Keuls Post-hoc Analysis

Symbolic Preference

Group	Black	Oriental	Anglo	Hispanic
Group Mean	24.229	21.772	21.212	20.472 *

*Significant at .05 level

Table 7

Analysis of Variance

Interaction Effect On Graphic Scores

Source	SS	df	MS	F	prob
Ethnicity X Achievement	199.362	3	66.454	3.590	.015
Within	3091.304	167	18.511		

Table 8

Analysis of Variance

Interaction Effect On Verbal Scores

Source	SS	df	MS	F	prob
Ethnicity X Achievement	19.883	3	6.628	.193	.8995
Within	5749.352	167	34.427		

Table 9

Analysis of Variance

Interaction Effect On Symbolic Scores

Source	SS	df	MS	F	prob
Ethnicity X Achievement	218.981	3	72.994	1.401	.243
Within	8698.092	167	52.084		

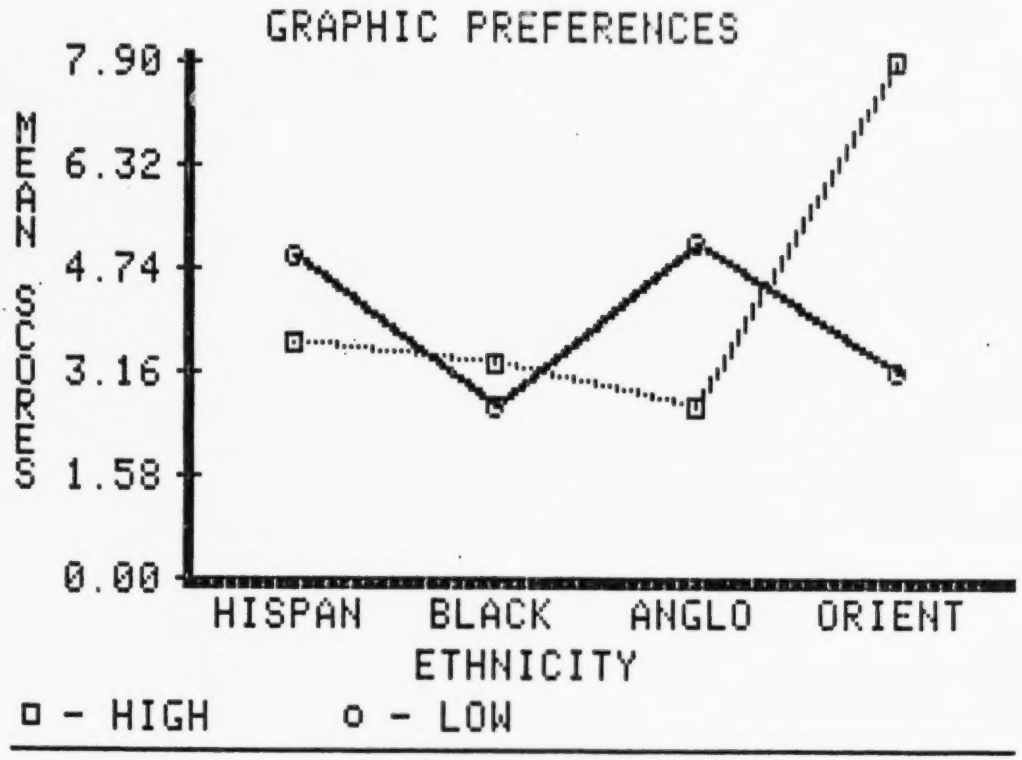
Table 10

Analysis of Variance

Achievement

Source	SS	df	MS	F	prob
Ethnicity	397.883	3	132.628	6.063	.0009
Within	3740.551	171	21.875		

Table 11



Mean Graphic Scores

	Hispanic	Black	Anglo	Oriental
High	3.59	3.23	2.63	7.85
Low	4.93	2.57	5.07	3.11

Figure 1

Newman-Keuls Post-hoc Analysis

Achievement

Group	Oriental	Anglo	Hispanic	Black
Group Mean	15.955	15.515	14.708	11.896***

***Significant at .01 level

Table 12

Analysis of Variance

Achievement Using Black Subgroup 1

Source	SS	df	MS	F	prob
Ethnicity	101.937	3	33.979	1.542	.205
Within	2930.472	133	22.034		

Table 13

Analysis of Variance

Achievement Using Black Subgroup 2

Source	SS	df	MS	F	prob
Ethnicity	202.841	3	67.614	3.158	.026
Within	2997.131	140	21.408		

Table 14

Analysis of Variance

Achievement Using Black Subgroup 3

Source	SS	df	MS	F	prob
Ethnicity	100.657	3	33.552	1.519	.211
Within	3158.622	143	22.088		

Table 15